Technology as Media: The Learner Centered Perspective

James A. Levin
Bertram C. Bruce

University of Illinois
Urbana-Champaign

Paper presented at the 2001 AERA Meeting, Seattle WA
Symposium 33.48
What Teachers Should Know about Technology? Perspectives and Practices

March 2001

Abstract

The balance between learning and doing is impacted by new technologies for learning. In this paper, we explore a framework for expertise that emphasizes the power of multiple coordinated representations. We use a learner-centered taxonomy of technology uses for learning as a framework for systematically developing powerful environments for learning.

Introduction

Why learn?

It may be somewhat heretical to raise this question, but why do/should people learn? To make this a plausible question, let us enumerate some of the costs of learning.

Costs of learning

There are at least six costs of learning.

- Learning takes time and effort by the learner. Not only are there direct costs to the learner and the society that the learner belongs to, but there are also opportunity costs. The time and effort spent on learning are time and effort that are not spent on other things, especially in our current schooled system in which learning is isolated from doing.
- Learning can also interfere (at least temporarily) with the performance of previously acquired expertise.
- Learning also requires the time and effort of others (teachers, mentors, others involved in the support of learning), again both with the direct and opportunity costs.
- Learning can lead to the disruption of group performance, again at least temporarily. The introduction of new knowledge or skills can impair the performance of an efficiently operating group.

- Learning consumes some of the resources of society, and thus competes against other demands on society's resources.
- Learning can lead to the disruption of social relations and the social structure of society, at least until a new equilibrium is reached.

Benefits of learning

Now that we have seen some of the costs of learning, we can of course enumerate the benefits. Learning allows individuals, groups, and societies to adapt to changing contexts much faster and much more effectively than other mechanisms (evolution, for example).

Balance between learning and doing

If we had a society in which nobody learned anything, there will be no good way for that society and the individuals in it could adapt to changes in the environment, and so the society would collapse when faced with significant changes faster than evolution operates and the individuals would die. On the other extreme, if we had a society in which individuals always learned and never performed, then the society would not produce the necessities of life and again would collapse. So we can see that there a need for a balance between learning and doing, in which the costs of learning are outweighed by the benefits of learning.

That balance can be impacted by the media available for learning. As the media change, then the costs of learning can change and the benefits of learning also can change. Let us look at a range of media, and examine in some depth the ways that they impact learners.

Media for learning

A Representational ToolKit model for expertise

What does it mean to have learned something? Over the past twenty years, there have been a series of studies of what distinguishes experts in a domain from novices (Chi, Feltovich, & Glaser, 1981; Chi, Glaser, & Farr, 1988; Larkin, McDermott, Simon, & Simon, 1980). In a number of different domains, the findings are consistent - experts have multiple ways of thinking about the domain, while novices have only one or a few ways. Experts have many different representations of the knowledge domain, they can switch from one representation to another, and they have the metaknowledge that allows them to know which representation to choose for which task and which representation to switch to while solving the task.

When an expert accomplishes a task smoothly, he/she uses this metaknowledge to select an appropriate initial representation for the task, typically a global, qualitative representation. The expert proceeds until metaknowledge indicates the value of switching to another representation, often more detailed and sometimes more quantitative (depending on the domain). Finally, the expert completes the task, after perhaps more switches of representations.

When an expert encounters a problem, he/she uses this metaknowledge to switch to a different

representation that may allow the expert to overcome the problem. If not, then the expert switches to yet another representation, until either the problem is solved or the expert has applied all representations.

One model for thinking about expertise in this way is the Representational Toolkit framework (Levin, Stuve, & Jacobson, 1999). An expert craftsman has a range of different tools, with skill at using each tool and knowledge of when to use each tool in sequence to accomplish a task. Similarly, an expert in a knowledge domain has a range of different knowledge representations, and the metaknowledge of which to use at different times. Debates about which is the "best" representation of a knowledge domain, in this model, may be similar to arguments about which is the "best" tool, a hammer or a saw.

Implications for the design of learning environments

What are the implications of this way of thinking about expertise for designing learning environments? One implication is that learning environments should be designed to help learners acquire multiple representations of the domain area. A second implication is that learning environments should help learners acquire skill at switching between one representation and another. In other words, the representations should be coordinated. A third implication is that learning environments should help learners acquire metaknowledge about these representations, including the metaknowledge of when to use each representation and when to stop using it and instead switch to another.

One of the strengths of new computer-based technologies is that they can display multiple presentations of knowledge in a domain to the learner at the same time, in a way that is coordinated. In other way, an action by the learner on one representation is automatically reflect in changes in all the other presentations. These multiple coordinated presentations can then support the acquisition of multiple coordinated representations. But how can we systematically think about multiple presentations, given the diversity of knowledge domains?

A taxonomy of uses of technologies for learning

Bruce & Levin (Bruce & Levin, 2001 in press; Bruce & Levin, 1997) proposed a taxonomy of uses of technologies for learning based on the natural impulses of a child proposed by John Dewey (Dewey, 1943): inquiry, communication, construction, and expression. In this taxonomy, the diversity of uses of technologies for learning is captured by these four different media for learning, based on the goals of the learner. Could this same framework help us to systematically think about the diversity of knowledge domains and therefore help us to construct learning environments that support the development of expertise? To explore this, let us examine each of the four categories to see.

Media for inquiry

Technologies can be used as media for learning through inquiry. The inquiry-based learning framework focuses on this particular set of uses. Innovative learning approaches in science,

mathematics, and engineering have concentrated on this set of uses (Bruce & Levin, 1997).

Inquiry can be used as the basis of a presentation mode. One example is the Inquiry Page <http://inquiry.uiuc.edu/>, a web-based portal of resources focusing on inquiry learning . Many other presentations are inquiry-oriented, especially those designed for science, either for learning or doing. The best examples of these science inquiry environments are the "workbench" web sites, for example, the Biology Workbench <http://biology.ncsa.uiuc.edu/> and the Biology Student Workbench <http://bioweb.ncsa.uiuc.edu/educwb/> . These are set up explicitly to facilitate inquiry processes, including the search of multiple databases and the analysis of retrieved datasets.

Media for communication

Technologies can also be used as media for learning through communication. Teaching, for example, is a specialized form of communication, and many of the existing and new technologies have served to support learning through teaching. There are also other communicative uses that can support learning, for example through communication with other learners or through communication with others outside the current educational system. Many of the innovative approaches to the use of new technologies for learning in the language arts, for example, have focused on media for communication (Bruce & Levin, 2001 in press).

Many innovative uses of technologies for learning have been communication presentations. Most of the "course package" web systems (WebCT, Blackboard, WebBoard) explicitly present a communicative model. There are conferences, homework drop-boxes, announcement sections, test sections, lectures and lecture notes…all forms of communication. Collaborative learning, especially that mediated through new technologies (CSCL), is another cutting-edge approach to learning.

Media for construction

Technologies can be used as media for learning through construction. The current constructivist approaches emphasize knowledge construction; in fact the new "constructionist" approach explicitly focuses on the construction of external artifacts as important for learning (Kafai & Resnick, 1996). Even for older Problem-based Learning and Project-based learning approaches, construction (either individually or jointly) plays a major role in learning.

Several uses of innovative technologies for learning have taken a "construction set" presentation mode.

Media for expression

Technologies can be used as media for learning through expression. This is a fairly frequent use of new technologies in the language arts (Bruce & Levin, 2001 in press). Much of the focus of theories

of writing and other creative arts deals with the "development of one's own voice" (Graves, 1983), which is a focus on self-expression.

One of the first tools developed for modern graphic interfaces was a series of painting and drawing programs (PaintPot from Xerox PARC; MacPaint from Apple). Computer-based photo editing, music editing, and video editing applications are example of new technologies oriented toward expression.

Summary

By examining both the costs and benefits of learning, we can see the impact that new technologies for learning have on the learner, the learning environment, and the larger society. The learner-based taxonomy of technology uses for learning when combined with emerging theories of the nature of expertise provide a basis for systematically designing more powerful contexts for learning.

References

Bruce, B., & Levin, J. (2001 in press). Roles for new technologies in language arts: Inquiry, communication, construction, and expression. In J. Jenson, J. Flood, D. Lapp, & J. Squire (Eds.), *The handbook for research on teaching the language arts*. NY: Macmillan.

Bruce, B. C. (2001). The Inquiry Page: A collaboratory for curricular innovation. *Learning Technology, 3*(1),

Bruce, B. C., & Levin, J. A. (1997). Educational technology: Media for inquiry, communication, construction, and expression. *Journal of Educational Computing Research, 17*(1), 79-102.

Chi, M. T. H., Feltovich, P. J., & Glaser, R. (1981). Categorization and representation of physics problems by experts and novices. *Cognitive Science, 5,* 121-152.

Chi, M. T. H., Glaser, R., & Farr, M. J. (Eds.). (1988). *The nature of expertise*. Hillsdale, NJ: Lawrence Erlbaum.

Dewey, J. (1943). *The child and the curriculum: The school and society*. Chicago: University of Chicago Press.

Graves, Donald H. (1983). *Writing: Teachers and children at work*. Portsmouth, NH: Heinemann Educational Books.

Kafai, Y. B., & Resnick, M. (1996). *Constructionism in practice: Designing, thinking, and learning in a digital world*. Mahwah, NJ: Lawrence Erlbaum Associates.

Larkin, J. H., McDermott, J., Simon, D. P., & Simon, H. A. (1980). Expert and novice performance in solving physics problems. *Science, 208,* 1335-1342.

Levin, J. A., Stuve, M. J., & Jacobson, M. J. (1999). Teachers' conceptions of the Internet and

the World Wide Web: A representational toolkit as a model of expertise. *Journal of Educational Computing Research, 21*(1), 1-23.